

# Colorectal Cancer in Rural Nebraska<sup>1</sup>

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## ABSTRACT

A case-control interview study of colorectal cancer was conducted in two rural counties of eastern Nebraska to determine reasons for the elevated colon cancer mortality rates during 1950 to 1969. Comparison of the information provided by 86 colorectal cancer cases and 176 matched controls (or their next of kin) revealed an increased risk among persons of Czech background, with persons of Bohemian and Moravian extraction predominating in this area. The data suggest an interaction between Bohemian ancestry and certain dietary patterns in the pathogenesis of colon cancer in this region. Colon cancer risk was elevated among commercial beer drinkers regardless of their ethnic background, although Bohemians reported heavier consumption. An excess risk was also associated with intestinal polyps, reported more often by Moravians, and with familial occurrence of gastrointestinal and other cancers. Since 1969, the mortality and incidence rates for colon cancer in this area have declined, possibly as a consequence of acculturation of the American-born descendants of Czech immigrants.

## INTRODUCTION

A survey of colon cancer mortality rates for United States counties during 1950 to 1969 showed that the highest rates were in the northeast and metropolitan centers around the Great Lakes (4, 27, 28). Both national (4) and international (40, 48) patterns show positive correlations with the degree of urbanization and socioeconomic status. Therefore, it was surprising to find a cluster of counties with high colon cancer mortality rates in eastern Nebraska (27), primarily a rural farming area. To evaluate this departure from the usual pattern, we conducted a case-control interview study of large bowel cancer among area residents; rectal cancer was included to avoid loss of cases due to misclassification by bowel segment.

We undertook this study with several *a priori* hypotheses regarding the excess mortality from colon cancer in the study area. (a) Because the area had a high concentration of Czechoslovakians, a group shown to have an elevated colon cancer risk by a previous nation-wide mortality survey (15), we wanted to examine the effects of factors unique to this ethnic group, such as certain dietary habits and beer consumption. (b) Emphasis was placed on obtaining family cancer histories because of the known familial component to large-bowel cancer (1) and the sizeable effect that a few cancer-prone kindreds in this sparse

population could have on the mortality rates of the area. (c) The rural nature of these 2 counties dictated a careful assessment of farming-related exposures.

## MATERIALS AND METHODS

Residents of Butler and Colfax counties, Neb., diagnosed during the period of 1970 to 1977 as having colorectal cancer [International Classification of Disease Nos. 153 and 154 (33)], were identified by searching the medical records of local physicians and all hospitals in the area, including those in adjacent counties and in nearby Lincoln and Omaha, to which residents might have been referred. For each case identified, 2 controls were selected from hospital admissions lists matched to the case by hospital, year of hospitalization, county of residence, age ( $\pm 5$  years), race, and sex. An attempt was made to select acute hospital admissions; patients with cancer of the breast, ovary, or endometrium, with coronary artery disease or with inflammatory bowel disease, including ulcerative colitis, were ineligible as controls. Coronary artery disease and cancer of the breast and reproductive organs were excluded because they are suspected, like colon cancer, to be related to dietary fat intake.

Face-to-face interviews were conducted at the home of either the subject or the nearest living relative of deceased subjects. Information was obtained on demographic, familial, and ethnic factors; medical, occupational, and residential histories; and lifetime alcohol, tobacco, and food consumption patterns. A brief telephone verification of selected responses was conducted for 5% of the questionnaires. Medical records of the cases were carefully checked for histological confirmation of the diagnosis and to ensure that the diagnosis noted between 1970 and 1977 was the first that had occurred for colorectal cancer. Verification of cancer incidence among relatives of the respondents through medical records and death certificates was conducted by one of the authors (H. T. Lynch); results of pedigree studies will be reported in a companion study (25).

With regard to diet, respondents were instructed to report "your (his/her) typical adult diet, from age 20 until prior to onset of your (his/her) illness." For individuals who had undergone major dietary changes (due to other illnesses, introduction of refrigeration on the farm, etc.), provision was made to collect up to 2 additional complete dietary histories. The most recent diet that was followed for at least 10 years (mean, 42 years) was used in the analysis; for 77% of the respondents, this was also the diet followed for the longest time. Frequencies of consumption were obtained for 57 food items (see "Appendix"). Appropriate food frequencies were summed to form total frequencies of consumption for various food groups. In addition, indices of micronutrient intake were developed for total vitamin A, carotene, retinol, and vitamin C as weighted sums of the frequencies of consumption of individual foods, with weights equal to the quantity of the micronutrient in a typical serving of each food item (42, 43).

**Statistical Methods.** Crude odds ratios were calculated (18, 47) separately for colon cancer and for rectal cancer for each qualitative response and for greater than the median frequency of consumption for each food item. Quantitative odds ratios were further examined by a test for trend with increasing use of the item in question (41).

The logistic model was used to examine the effects of potential confounders and to obtain maximum likelihood estimates of the adjusted

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odds ratios (37, 38) associated with Czech ancestry, cancer among first-degree relatives, selected chronic diseases, farm chemical use, and consumption of alcohol, major food groups, and certain micronutrients. Potential confounders included indicator variables for sex (both of the subject and of the respondent, if next-of-kin), age (<70, 70 to 79, and 80+ years old), usual county of residence, usual residence within town limits, education, vital status of study subject, and ethnic group (Bohemian, Moravian, and other); interactions between variables and case-control status were included in the model as potential effect modifiers. Type of farm was included as a potential confounder for the analysis of farm chemical use, and indicators of obesity, vitamin pill use, and alcohol and tobacco use were added for the dietary analyses.

Decisions concerning parameter deletions were based on the *t* statistics for significance of the individual parameter estimates, on changes in the value of the log likelihood, and on the goodness of fit of the model, as measured by the comparison of predicted to observed stratified observed odds ratios. Interval estimates presented for these odds ratios ( $\theta$ ) are of the form,  $\exp [\ln \theta \pm 2 (\text{S.E. of } \ln \theta)]$ , with S.E. obtained from the inverse of the information matrix from each final model. These intervals may be interpreted as either 2-unit support intervals (11) or approximate 95% confidence intervals, although no adjustment of the confidence coefficient has been made to account for the multiple comparisons performed.

## RESULTS

A total of 96 cases of colorectal cancer diagnosed during 1970 to 1977 and 197 controls were identified among residents of Butler and Colfax counties. Interviews were successfully completed for 94% of the cases and 90% of the controls. Of those not interviewed, the respondent had moved out of the area or could not be located (5 controls), was too ill to be interviewed (2 cases and 5 controls), or refused to participate in the study (4 cases and 7 controls). Of the completed interviews, 4 cases and 2 controls were dropped for poor quality of response, leaving 86 cases and 176 controls for analysis.

The study subjects, all of whom were white, were generally elderly long-time residents of the study area (mean age, 74 years; mean length of residence, 45 years). Table 1 summarizes the vital status and sex of the members of the study group. The subjects were nearly equally divided between males and females (49% males) and between residents of the 2 counties (51% in Butler county); 75% had not completed high school. The majority of questionnaires was completed by surrogate respondents (60% for cases and 51% for controls), usually the spouse or offspring of the study subject. Controls were primarily accident victims or persons hospitalized for acute respiratory infections.

**Incidence Survey.** Although the observed proportional distribution of cases by specific bowel segment<sup>3</sup> resembled that seen in the Third National Cancer Survey of 1969 to 1971 (9), there was an overall deficit of cases of colorectal cancer compared to the number expected (94 observed and 116 expected, based on incidence rates from the neighboring state of Iowa, which participated in the Third National Cancer Survey). This apparent deficit of cases in an area where we expected an excess was examined in more detail by comparing sex-, age-, and segment-specific incidence rates in our study population with the corresponding rates recorded by the Third National Cancer Survey for the state of Iowa. Sex- and age-specific rates for the 2 areas were similar

Table 1  
Distribution of cases and controls by sex and vital status

	Males		Females		Total
	Alive	Deceased	Alive	Deceased	
Controls	44	45	43	44	176
Cases					
Colon cancer	11	15	13	19	58
Rectal cancer	5	9	5	9	28

except for the oldest age group (74+), with Nebraska males having lower rates and females having higher rates than those seen in Iowa.

A comparison of observed and expected numbers of cases according to bowel segment indicated that the overall deficit of cases was limited to the colon; the total observed number of rectal cancer cases (32 cases) was nearly identical to the expected number (33.9 cases), although a higher proportion than expected was reported in the rectosigmoid junction area. A deficit of colon cancer cases was seen also when the age-standardized incidence rates observed for our study area (1970 to 1977) were compared to rates in other areas of the country (Table 2). A decreasing incidence of colorectal cancer in Butler and Colfax counties is suggested by the decline of colon cancer mortality rates in the area during each 5-year interval from the period of 1950 to 1954 to the period of 1970 to 1975 (from 28 to 22 per 100,000 for males; from 34 to 14 per 100,000 for females). The mortality data from 1970 to 1975 were not available at the time this study was initiated.

**Ethnicity.** Respondents were asked to name their major ancestral groups (up to 2 groups/parent), their birthplaces, and those of their parents and grandparents. Czechoslovakians were asked specifically if their families were from Bohemia, Moravia, or Slovakia, the 3 sections of what is now Czechoslovakia. Half of the study population was of Bohemian extraction, but the logistic analysis indicated that the smaller group of Moravians had the highest overall odds ratios for both colon and rectal cancer (Table 3). An analysis of birthplace led to the same conclusion as the analysis of ancestry alone. Only 9% of all study subjects were foreign born (7 cases and 17 controls); no trend was seen in the odds ratios with increasing numbers of foreign-born parents or grandparents or with recency of migration to the United States.

**Farming.** Most men in the area were farmers (87%); most women never worked outside the home or family farm for more than 6 months during their lifetime. Although not statistically significant, a 2-fold elevation in the odds ratio for rectal cancer was seen for both males and females who had ever farmed, independent of the length of time they had been farming [ $\theta = 2.06$ ; interval estimate = (0.70, 6.05)].

Chemicals reportedly used on the farm were grouped into the following broad categories: crop insecticides, livestock insecticides, herbicides, fungicides, and bacteria inoculants. The colon cancer odds ratios for each of these groups were elevated, especially for fungicide use (7 cases and one control), while the rectal cancer odds ratios were consistently below one. However, fewer than 25% of the study subjects reported any chemical use.

**Medical History.** The presence of intestinal polyps was strongly associated with both colon and rectal cancer [ $\theta = 4.58$  (1.53, 13.69) and 5.25 (1.50, 18.37), respectively, based on 9

<sup>3</sup> Specific bowel segments and corresponding International Classification of Diseases codes were: cecum, appendix, and ascending colon (153.0); transverse colon (153.1); descending colon (153.2); sigmoid colon (153.3); colon not otherwise specified (153.8); rectosigmoid junction (154.0); and rectum (154.1).

Table 2  
Average annual age-standardized incidence and mortality rates per 100,000 in eastern Nebraska and other selected areas of the United States

Location	Incidence <sup>a</sup>			Mortality <sup>b</sup>				
	Conn., 1969-1971	United States, all Third National Cancer Survey areas, 1969-1971	Colfax and Butler counties, Nebr., 1970-1977	Conn.	United States total	Nebr. total	Colfax	Butler
Colon								
Male	30	25	17	20.3	16.5	16.6	23.5	27.1
Female	26	22	18	19.1	16.3	17.1	24.1	27.4
Rectum								
Male	18	14	11	9.9	7.7	6.4	3.9	7.3
Female	10	8	7	5.7	4.8	4.0	3.0	4.8

<sup>a</sup> Age-standardized to 1970 "world" population (4).

<sup>b</sup> Rates for 1950 to 1969, age-standardized to 1960 United States population (2).

Table 3  
Odds ratios for Czechoslovakian ancestry  
Odds ratios were calculated versus group with no reported Czech ancestry; logistic model included sex and county of residence as potential confounders.

Ethnic group	No. of controls	No. of cases		Odds ratios	
		Colon	Rectum	Colon	Rectum
Bohemian only	68	23	11	1.28 (0.62, 2.64)	1.17 (0.44, 3.15)
Bohemian/Moravian	18	7	4	1.56 (0.55, 4.43)	1.82 (0.48, 6.87)
Moravian only	18	9	4	1.92 (0.70, 5.25)	1.90 (0.50, 7.29)

Table 4  
Odds ratios for cancer among first-degree relatives  
Odds ratios were calculated versus the group of persons reporting no cancer among first-degree relatives (95 controls, 23 colon cases, and 9 rectum cases). Logistic model included sex and usual residence in town as potential confounders. Note that the column totals for specific sites will not equal the number of persons reporting any cancer, since several relatives could have had cancer at different sites. Multiple occurrences of a single cancer site within a family, however, are only counted as one report of a family history of cancer at that site.

Site (International Classification for Diseases no.)	No. of controls	No. of cases		Odds ratios	
		Colon	Rectum	Colon	Rectum
Any (140-209)	81	35	19	1.74 (0.94, 3.25)	2.51 (1.05, 6.04)
Respiratory tract (160-163)	10	3	2	1.09 (0.26, 4.50)	2.13 (0.37, 12.36)
Breast (174)	11	5	4	1.96 (0.58, 6.66)	4.81 (1.09, 21.30)
Digestive system (150-159)	33	21	13	2.48 (1.19, 5.17)	4.33 (1.64, 11.46)
Colorectal cancer (153, 154)	12	11	8	3.72 (1.40, 9.85)	15.90 (3.79, 66.66)
Stomach cancer (151)	13	11	1	3.30 (1.27, 8.58)	0.91 (0.09, 9.58)
Genitourinary system (180-189)	10	7	5	2.71 (0.88, 8.38)	7.25 (1.68, 31.30)
Lymphatic and hematopoietic (200-209)	8	1	3	0.47 (0.05, 4.21)	4.07 (0.87, 19.00)
Cancer not otherwise specified (140-149, 170-173, 190-199)	26	6	5	0.93 (0.33, 2.59)	2.01 (0.60, 6.72)

colon cancer cases, 5 rectal cancer cases, and 7 controls]. Although persons of Moravian ancestry were more likely to report a history of polyps (15% versus 6% of others), no significant differences in the odds ratios were seen among the various ethnic groups. It was not possible to determine whether any of these represented the occurrence of hereditary polyposis. Odds ratios for both sites were also elevated for subjects who reported a history of colitis or ileitis [ $\theta = 1.42$  (0.53, 3.78) for colon; 2.69 (0.83, 8.66) for rectum]. No statistically significant associations were observed with any other medical conditions (e.g., diverticulosis, ulcers, or hemorrhoids) or surgical procedures, although a 2-fold rectal cancer increase was seen for females who had had gallbladder surgery (6 of 14 cases; 22 of 67 controls). No significant differences were observed in bowel habits between cases and controls, even when responses of next-of-kin were disregarded.

**Family History.** A complete history of the occurrence of cancer among the relatives of subjects was recorded as recalled by the

respondent. For purposes of this analysis, only cancer among first-degree relatives (parents, siblings, and offspring) was considered. Odds ratios for cancer of all sites combined (International Classification of Diseases Nos. 140 to 209) among first-degree relatives were elevated for both colon and rectal cancer cases (Table 4), with the odds ratio for rural patients with rectal cancer being especially high [ $\theta = 7.14$  (1.87, 27.27)]. This excess rose dramatically with increasing numbers of first-degree relatives affected ( $\theta = 3.64, 4.92$ , and 19.67 for cases with 1, 2, and 3+ affected relatives, respectively; test for trend  $z$  statistic, 4.50;  $p < 0.001$ ). No similar trend in the odds ratios was evident for town residents or for rural residents with colon cancer. Significant increases in the site-specific odds ratios were seen for cancers of the colon and stomach among relatives of colon cancer cases and for colon, breast, and prostate cancer (4 cases and 2 controls) among relatives of rectal cancer cases. Persons of Moravian and/or Bohemian descent were no more likely than other subjects to report colon or other cancer among first-degree

Table 5  
Mean anthropometric measurements for cases and controls, according to sex

	Males			Females		
	Ht (inches)	Usual adult wt (lb)	Ponderal index <sup>a</sup>	Ht (inches)	Usual adult wt (lb)	Ponderal index <sup>a</sup>
Controls	69 ± 0.3 <sup>b</sup>	172 ± 2.0	25.3 ± 0.3	64 ± 0.2	140 ± 2.0	30.3 ± 0.4
Cases						
Colon	70 <sup>c</sup> ± 0.6	182 ± 5.8	25.7 ± 0.7	63 ± 0.6	146 ± 4.3	31.6 ± 0.9
Rectum	70 ± 0.7	169 ± 3.4	24.1 <sup>c</sup> ± 0.4	63 ± 0.9	141 ± 5.8	31.5 ± 1.1

<sup>a</sup> Ponderal index is usual adult weight/height<sup>p</sup>, where  $p = 1.5$  for females and  $p = 2$  for males; expressed as kg/m<sup>p</sup>.

<sup>b</sup> Mean ± S.E.

<sup>c</sup> Case measurement significantly different from control ( $t$  statistic, >1.65).

relatives.

**Anthropometry.** The mean usual adult weight for the colon cancer cases was higher than for the controls (Table 5), and an elevated odds ratio was seen for both male and female colon cancer patients who were at least 10% over the ideal weight for their age group (34) [ $\theta = 3.80$  (1.33, 10.89); mean ponderal indices for this obese group were 30.0 kg/sq m for males, and 38.9 kg/m<sup>1.5</sup> for females]. Although the proportion of Czechs who were overweight was nearly twice that of the other study subjects (7.4% versus 4.0%), controlling for ancestry did not affect the odds ratio. These results suggest an influence of obesity on the area's high colon cancer rates, since the mean heights and weights of the control group approximate the United States average seen in a recent nation-wide survey (34).

**Tobacco Use.** Patterns of cigarette consumption among male subjects closely resembled those for males over age 64 in a recent national survey (44), while few (9%) female subjects ever smoked. No significant associations were observed for any tobacco products.

**Alcohol Use.** Over half of the study subjects drank beer or wine at least occasionally (78% males; 39% females). Because it was suspected that beer consumption patterns varied among the ethnic groups in the area, odds ratios were calculated according to whether the patient usually drank commercial or homemade beer. Although ethnicity was not a statistically significant confounder, not only were Bohemians more likely than Moravians or non-Czechs to report any beer consumption, but their reported frequency of consumption was twice that of the other ethnic groups for both commercial and homemade beer. As shown in Table 6, the positive association between large-bowel cancer and beer drinking was limited to commercial beer consumption, and was stronger for colon than for rectal cancer. The quantity of commercial beer consumed by males could be stratified into <1, 1 to 6, and 7+ servings/week with corresponding colon cancer odds ratios of 3.37, 3.58, and 5.30 relative to non-beer drinkers (test for trend  $z$  statistic, 1.95;  $p = 0.05$ ). Small numbers precluded similar analyses for females and for rectal cancer. A similar analysis revealed no excess risk associated with either homemade or commercial wine.

**Dietary Habits.** Positive associations were seen between colon and rectal cancer and increased consumption of meats/dairy products/eggs, sweets, vegetables and, to a lesser extent, processed meat (Table 7). Reduced odds ratios for rectal cancer were associated with a high intake of grains (especially whole grains) and high-fiber foods, but elevated odds ratios for colon cancer were seen for frequent consumers of these foods. None of the odds ratios shown in Table 7, however, was significantly different from 1.0. A stratified analysis of low, moderate, and

Table 6  
Odds ratios for consumption of beer and wine

Odds ratios for usual frequency of consumption were more than zero servings/week. Referent group consists of persons reporting no consumption of beer or wine, either commercial or homemade. Logistic model included sex, ever smoked cigarettes, and ever smoked a pipe as potential confounders.

	Type usually consumed	% of consumers	Colon	Rectum
Beer	Commercial	46	2.70 (1.31, 5.54)	1.40 (0.53, 3.67)
	Homemade	12	0.81 (0.18, 3.78)	1.17 (0.24, 5.61)
Wine	Commercial	34	1.16 (0.33, 2.34)	0.88 (0.33, 2.34)
	Homemade	18	0.47 (0.16, 1.36)	1.36 (0.47, 3.92)

Table 7  
Odds ratios for consumption of food groups (greater than median frequency)

Food group (food item no. <sup>a</sup> )	Median no. of servings/wk <sup>b</sup>	Odds ratios <sup>c</sup>	
		Colon	Rectum
All meat (1-7, 9-13)	12.6	1.71	1.06
Red meat (1, 2, 4, 7)	6.0	1.09	1.25
Poultry (5, 6, 12, 13)	2.0	1.13	1.38
Organ meat (9)	0.2	0.86	1.00
Processed meat (3, 10, 11)	3.0	1.16	1.37
Dairy products (15-18, 49, 52, 53)	27.0	0.74	0.92
Meat, dairy products, eggs (1-7, 9-18, 49, 52, 53)	44.9	1.20	1.68
Sweets (25, 49-51, 56)	8.5	1.40	1.62
Butter, margarine, salad dressings, sauces (18-21)	23.1	1.09	0.96
Fruits, vegetables (33-48)	21.3	0.97	1.21
Fruits (33-37, 48)	11.8	1.12	0.97
Vegetables (38-47)	8.9	1.77	1.43
Green (38, 40, 42, 44, 47)	5.0	1.21	0.95
Brassica (38, 45)	1.0	0.78	1.22
Whole grains (22, 26, 27)	4.5	1.48	0.61
Nuts, legumes (32, 39, 42)	3.2	1.08	2.04
Grains, grain products (22-29)	23.0	1.30	0.77
High-fiber foods (22, 26, 27, 30, 32-47)	33.0	1.77	0.73

<sup>a</sup> See "Appendix."

<sup>b</sup> Minimum estimates of intake, due to the limited number of foods included in the dietary questionnaire.

<sup>c</sup> Odds ratios resulting from logistic models including as potential confounders: Bohemian ancestry, Moravian ancestry, sex, age ≥80 years, and usual residence in town. Referent group consists of persons with frequency of consumption less than the median.

high consumption of the various food groups (categorized by tertiles of consumption) supported the results of the logistic analysis for both colon and rectal cancer. Odds ratios for persons

with diets high in vitamins A and C, as estimated by our micro-nutrient indices, were similar to those for persons with diets high in foods from the contributing food groups.

The logistic analyses detected strong effects of age, sex, town residence, and ancestry on food consumption patterns. For example, males consumed significantly more eggs, potatoes, coffee/tea, and beer/wine than did females, and consumed significantly fewer servings of fruit, green vegetables, and whole grains. A positive association was noted between age and increased consumption of poultry, dairy products, total grains and whole grains, potatoes, and foods high in fiber. An inverse relationship was seen between age and the consumption of red meat and coffee/tea. Odds ratios for these food groups did not vary, however, across the sex/age subgroups.

Bohemian ancestry had such a significant effect on the relationships between cancer risk and food consumption that odds ratios are presented separately for this ethnic group in Table 8. Odds ratios for meat, dairy products, butter/margarine, *Brassica* vegetables, and grains were elevated for both cancer sites among Bohemians but were reduced among non-Bohemians. No specific food items unique to Bohemians could be identified to account for the observed patterns of risk.

Similar analyses were performed to estimate odds ratios associated with the consumption of pickled, smoked, or charcoal-broiled meats (beef, pork, poultry, and fish). Only the rectal cancer odds ratio for smoked beef was elevated [ $\theta = 2.69$  (1.01, 7.18)], with the remainder of the estimates being less than or equal to one. The pickling process, more commonly used by Czechs than by other area residents, was associated with reduced odds ratios for both sites, but there was no risk gradient with the varying consumption of pickled meats.

**Confounding of Czech Risk by other Factors.** Associations between Bohemian and Moravian ancestry and other risk factors for colon cancer suggested by this study were examined by means of a logistic analysis. Indicator variables were included in the model for the presence of intestinal polyps, employment as a farmer, colon cancer among first-degree relatives, being at least 10% over ideal weight, any beer consumption, and consumption over the median amount of all meats, dairy products, meat/dairy products/eggs, sweets, all vegetables, *Brassica* vegetables, and high-fiber foods. The odds ratio for Bohemian

ancestry was reduced from 1.31 to 1.21 (0.60, 2.44) by controlling for the consumption of beer, sweets, and all vegetables, the most significant confounders noted. Similarly, the odds ratios for Moravian ancestry was reduced from 1.68 to 1.41 (0.59, 3.35) by controlling for the presence of polyps and the consumption of beer and high-fiber foods.

## DISCUSSION

The geographic patterns of colorectal cancer have indicated positive correlations with urbanization, socioeconomic status, and the "western" type of diet (8). National and international studies of *per capita* consumption have also suggested associations with diets high in fat, meat, and cholesterol, and possibly beer consumption, and with diets low in fiber intake (2, 3, 5, 8, 12, 19, 24, 30). Although the mechanisms of colon carcinogenesis appear to be complex, studies in laboratory animals have suggested that dietary fat may act as a promoting agent (6, 46), while protective effects may be exerted by fiber, vitamins A and C, and indole compounds present in vegetables of the *Brassica* genus (35, 39, 45). Results of several case-control studies of colorectal cancer have been inconsistent, although some suggest the influence of high meat or fat intake (10, 16, 20, 36), and others implicate insufficiencies of dietary fiber and of fruits and vegetables, including those of the *Brassica* group (3, 14, 17, 31).

Our study was designed to clarify the dietary and other risk factors that may have been responsible for the high mortality rates of colon cancer in eastern Nebraska from 1950 to 1969. This geographic specificity limited the population available for study and may preclude extrapolation of our findings to the general population. It is noteworthy, however, that the mortality rates for colon cancer declined in the area during the subsequent period of 1970 to 1975, and that the recent incidence rates documented in our study were not excessive despite intensive case-finding efforts. This trend suggests that the elevated mortality before 1970 reflects the lifestyle practices of Czech immigrants, now operating to a lesser degree among their descendants, but which still may be detected among the elderly subjects of this study.

The results are consistent with our hypothesis that persons of Czechoslovakian descent contributed to this elevated risk, apparently because of differences in dietary practices, beer consumption, and body weight. Elevated risks for colon cancer were associated with a high-fat diet among Bohemians, particularly from meat and dairy products. No specific ethnic characteristics or food items could be clearly implicated in the susceptibility of Czech residents to colon cancer, but the sensitivity of our questionnaire to detect ethnic differences in food preparation methods was rather limited. The apparent confounding between ethnicity and diet suggests that the Czechs, particularly Bohemians, may be more susceptible to the effects of certain nutritional risk factors for large-bowel cancer and do not enjoy the protective effects of foods such as whole grains and *Brassica* vegetables that have been noted in other populations. An excess risk of colon cancer was also associated with obesity, consistent with previous studies (8, 23), and with beer drinking, although earlier surveys have related beer consumption to rectal cancer alone (8).

A 3-fold excess of colon cancer was found among patients with a history of colon cancer in a close relative. This is consistent with previous surveys of familial risk of colon cancer (8), sug-

Table 8

Selected odds ratios for food consumption greater than the median frequency by ethnic group

Odds ratios are as in Table 6, but with the addition of Bohemian ancestry as an effect modifier.

Food group	Colon		Rectum	
	Bohemian	Non-Bohemian	Bohemian	Non-Bohemian
All meat	2.20	1.32	2.07	0.48
Red meat	1.79	0.65	1.79	0.84
Processed meat	1.90	0.69	2.46	0.71
Dairy products	1.74 <sup>a</sup>	0.28 <sup>b</sup>	2.59	0.27
Meat, dairy products, eggs	2.95	0.46	5.30 <sup>b</sup>	0.51
Sweets	1.39	1.42	5.73	0.46
Butter, margarine, salad dressing, sauces	1.58	0.75	2.39	0.35
Fruits	1.45	0.85	0.36	2.83
<i>Brassica</i> vegetables	1.31	0.43	1.86	0.75
Grains, grain products	1.88	0.88	2.32	0.20 <sup>b</sup>

<sup>a</sup> Interval estimate does not overlap that for non-Bohemians.

<sup>b</sup> Interval estimate does not include 1.0.

gesting that a concentration of unusually high-risk families does not explain the elevated rates in this area. Of interest, however, was the excess risk of other cancers among close relatives, including cancers elsewhere in the digestive tract, and in the prostate and breast. It has been speculated that the risk of the latter tumors are influenced by endogenous hormone levels (29) which in turn may be related to dietary fat intake. It is difficult to distinguish between genetic and environmental determinants of these familial occurrences, but detailed pedigree studies are now underway in an effort to clarify the patterns observed (25). The association between preexisting intestinal polyps and colon cancer seemed most pronounced among patients of Moravian ancestry, but we were unable to determine whether any cases had hereditary polyposis of the colon.

The results of this study must be interpreted with caution because of the small size of the population, the declining rates in the survey area, and inherent problems of dietary assessment. The elevated risk for colon cancer found among persons of Czech background in this area is consistent with the high rates described previously among Czech migrants to the United States (15), and with associations noted in a correlation study comparing colorectal cancer mortality in relation to ethnicity in United States counties (4). It is noteworthy that the mortality rates for colon cancer in Czechoslovakia are the highest in eastern Europe, although not as high as the rates prevailing in western Europe and North America (7). Incidence data for Czechoslovakia are generally sparse, but higher rates have been reported in the western area (Bohemia-Moravia) than in the eastern region of the country (Slovakia), and have been attributed to regional patterns of dietary fat consumption (13).

The inconsistent results from various nutritional studies of colorectal cancer may be partly due to different methods of collecting, aggregating, and analyzing dietary information. Although we would prefer information on the amount, frequency, storage, and preparation methods of many food items consumed over a long period of time, case-control studies of chronic diseases must rely on reports of the usual frequency of consumption of a limited number of food items provided by elderly study subjects who are seriously ill, or by their next of kin. While there are obvious problems of recall with this method, several studies have shown the validity of assessing dietary intake from next-of-kin responses (21, 22) and of categorizing the intake for broad food groups (e.g., as high, moderate, and low consumption) by grouping responses to individual food items (26, 32), as we have done. Inconsistent findings may also result from the failure to account for important confounding in the analysis. We noted strong effects of age, sex, ancestry, and occupation (farming *versus* other) on the consumption of most food groups and alcohol, chemical use, and meat preparation methods. This illustrates the importance of examining and controlling for potential confounding variables in order to unmask the patterns of risk associated with dietary and other lifestyle practices.

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## APPENDIX

For each of the following foods, respondents were asked: "Please tell me how often you (your —) ate the food on a daily, weekly, or monthly basis from the time you (your —) were 20 years old."

- |   |   |
|---|---|
| 1. Beef   | 30. White potatoes  |
| 2. Pork   | 31. Peanut butter   |
| 3. Bacon or sausage   | 32. Nuts  |
| 4. Lamb or mutton   | 33. Raw apples  |
| 5. Chicken or turkey  | 34. Berries, e.g., strawberries or blueberries                                  |
| 6. Duck or goose  | 35. Cherries  |
| 7. Wild game, e.g., venison, rabbit, or quail                           | 36. Grapefruit  |
| 8. Fish (fresh, frozen, or canned)                                      | 37. All other fruit, e.g., peaches, pears, or bananas                           |
| 9. Organ meats  | 38. Broccoli or brussels sprouts  |
| 10. Weiners or lunch meat   | 39. Dried peas or beans   |
| 11. Corned beef or pastrami   | 40. Greens, e.g., spinach or kale   |
| 12. Capons  | 41. Parsnips  |
| 13. Charcoal-fed poultry  | 42. Sweet peas  |
| 14. Eggs  | 43. Winter squash, sweet potatoes, or yams                                      |
| 15. Cheese  | 44. Green beans   |
| 16. Milk  | 45. Cabbage   |
| 17. Yogurt  | 46. Sweet corn  |
| 18. Butter  | 47. All other vegetables, e.g., carrots, celery, or lettuce                     |
| 19. Margarine or oleo   | 48. Fruit or vegetable juice  |
| 20. Salad dressing or mayonnaise  | 49. Ice cream, pudding, or custard  |
| 21. Gravy or cream sauce  | 50. Chocolate candy   |
| 22. Whole-grain (whole-wheat or pumpernickel) breads, muffins, or rolls | 51. Other candy   |
| 23. Refined (white, corn, or light rye) breads, muffins, or rolls       | 52. Cream   |
| 24. Doughnuts, pancakes, or waffles                                     | 53. Canned milk   |
| 25. Cake, cookies, or pie   | 54. Coffee  |
| 26. Bran or bran cereals  | 55. Tea   |
| 27. Oatmeal, cracked wheat, or granola                                  | 56. Soda pop  |
| 28. Cold cereal   | 57. Spicy condiments, e.g., mustard, horseradish, chili peppers, or chili sauce |
| 29. Noodles, macaroni, spaghetti, rice, or dumplings                    |   |

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